Introduction

Many firms focus on innovation as a central component of their strategy to achieve a competitive advantage over their rivals. To this end, companies exploit a variety of sources of innovation, both within and outside the boundaries of the firm. In-house research and development leading to product or process innovations offer certain advantages relative to outsourcing, due in particular to the transaction costs associated with contracting for knowledge. At the same time, in-house innovation is costly and fraught with risk. Furthermore, the locus of knowledge production seems to be increasingly distributed across organizational and national boundaries. As such, technology transfer plays an important role in innovation strategy for many firms.

In my paper with Rebecca Henderson (Agrawal and Henderson, 2002), we focus our attention on technology transfer from a particular source: two academic departments at MIT (mechanical engineering and electrical engineering/computer science). We report a series of descriptive statistics that lend support to three arguments: 1) the patenting channel is small relative to other channels of knowledge transfer, such as consulting, publishing, and recruiting graduate students, 2) the patenting channel is not representative of other channels (i.e., the set of firms that accesses MIT knowledge through patents is somewhat distinct from the set that accesses MIT knowledge through publishing), and 3) from a knowledge supply perspective, patenting activity does not appear to substitute for publishing.

In this chapter, I outline how each of these arguments links to current issues in strategy research. Furthermore, I discuss developments in the literature related to each since the article was originally published. Finally, I highlight areas associated with each argument that are now at the frontier of the literature and offer opportunities for future research. I address each of the three arguments this way in turn.

Patents Are of Limited Importance in Knowledge Transfer

This finding links to the current debate in strategy research concerning the importance of patenting in the transfer of technology. The strategic role of patenting, especially for new entrants, is perhaps best described in Teece (1986) and Gans and Stern (2003). These papers present conceptual frameworks that articulate the conditions under which firms will optimally engage in the market for ideas (e.g., license) rather than the product market. These conditions depend on the appropriability regime (i.e., the degree to which patents may be used to effectively protect intellectual property and thus facilitate trade) and the ownership and market structure associated with complementary assets.

Despite the emphasis these papers place on the importance of appropriability conferred by patents for profiting from innovation in the market for ideas, are patents really necessary to effectively trade in knowledge? Our data suggest that, at least in the university setting, patents are not always, nor often, necessary. This is at least partly because universities have welfare-maximizing rather than profit-maximizing objectives. Still, one might reasonably assume that receiving firms would be hesitant to invest in new product

development without assurance of a monopoly over the outcome of their labors (Agrawal and Garlappi, 2007). Furthermore, recent empirical evidence indicates that university inventors do have at least some tendency to behave in a profit-maximizing manner with respect to the commercialization of their research (Lach and Schankerman, 2005).

Thus, our data point to the importance of human interaction in effectively transferring new knowledge for commercialization purposes. We report knowledge transfer from university labs to firms through consulting, publishing, and recruiting graduate students as significantly more important that the use of patents. Cohen et al (1998) report similar results based on a demand-side survey (i.e., firms that utilize university technology). Further, in a separate paper, I report that even those inventions that were patented and licensed were more likely to be successfully commercialized if the licensee engaged the inventor (i.e., face-to-face interaction with the professor, post-doc, or graduate student) in the commercialization process (Agrawal, 2006).

The importance of human interaction has been further underscored by the non-university-focused literature on the geographic localization of knowledge spillovers (Jaffe et al, 1993; Thompson and Fox-Kean, 2005). Using patent citation data as a proxy for knowledge flows, these papers find that, despite the wide accessibility of knowledge contained in patented inventions (i.e., the details of the invention are described in the claims of the patent), subsequent innovation that builds on the focal invention is disproportionately co-located

with the inventors of the focal invention, even after controlling for the underlying geographic distribution of technological activity by technical field.

Following earlier research conducted by scholars such as Almeida and Kogut (1999), who report results suggesting that inter-regional labor mobility may be a cause of knowledge localization, recent empirical studies have sought to further explain why knowledge flows are geographically localized. The dominant hypothesis concerns the importance of human interaction in knowledge transfer. For example, Singh (2005) shows that knowledge flows disproportionately through social networks developed through research collaborations, Agrawal et al (2006) show that knowledge flows go disproportionately back to an inventor's prior city even after the inventor has moved, presumably due to social relationships that persist after geographic separation, and Agrawal et al (2007) show that social proximity (proxied by co-ethnicity) substitutes for geographic proximity in terms of mediating knowledge flows between individuals.

Why is human interaction so important in knowledge transfer? Most arguments hinge on the notion of tacit knowledge – knowledge that cannot be codified. Agrawal (2006) argues that the tacit condition may be unnecessarily strict since knowledge that is useful for commercializing an invention is often not impossible or even highly costly to codify, but there are missing incentives to codify due to the norms of patenting and publishing.

Understanding why human interaction is so important for technology transfer is now at the forefront of strategy research on this topic. We need to move beyond the simple taxonomy of knowledge as either tacit or codified and develop a more nuanced characterization of different forms of knowledge that may be more effectively transferred through particular channels. In addition, we need to better understand the differences in how markets operate for each of these types of knowledge, recognizing that even university technology transfer represents a two-sided exchange that must involve a willing buyer and seller (e.g., the licensee and inventor).

For example, the field would greatly benefit from detailed empirical work that explores the relationship between the variation in contracting terms and the type of knowledge being transferred. Increasing the granularity of our understanding of the asset of interest (knowledge) and the markets in which it is traded will allow the field to press forward and make progress on the question of central import, which concerns firm-level strategies that influence technology transfer effectiveness and ultimately sustainable competitive advantage reflected in superior firm performance.

Patenting Channel is Not Representative of Other Technology Transfer Channels

This finding links to the current issue in strategy research concerning the heavy use of patent data in empirical research on innovation and technology transfer. Early work on innovation and knowledge transfer by scholars such as Zvi Griliches (see Griliches (1998) for a survey of his early work) was very labor intensive as it required tedious data collection

involving the assembly of information by hand from hard copies of patents. The publication of patent data by the United States Patent and Trademark Office in machine readable electronic format dramatically lowered the cost of utilizing patent data for empirical research.

Two other major events further increased the value and hence popularity of patent data for innovation-oriented empirical research. First, Adam Jaffe, Manuel Trajtenberg, and Rebecca Henderson (Jaffe et al, 1993) famously responded to Paul Krugman's complaint (Krugman, 1991) that knowledge flows were ephemeral and could not be measured by showing how patent citation data could be used to do just that. This spawned a variety of literatures that rely heavily on citation data to measure knowledge flows.

Second, Bronwyn Hall, Adam Jaffe, and Manuel Trajtenberg cleaned the US patent data, added information such as aggregated technological classifications, and made these data widely available through the National Bureau of Economic Research (Hall et al, 2001).[1] This further lowered the cost and increased the value of using patent data for empirical research on innovation.

Additionally, the field has experienced a reasonable degree of increasing returns from patent-based research since as more scholars use patent data, more are familiar and comfortable with its use. Moreover, due to the growing use of patent data, scholars

[1] Interestingly, Professors Jaffe, Trajtenberg, Henderson, and Hall are all students of Zvi Griliches (see http://people.bu.edu/cockburn/tree_of_zvi_4_generations.pdf).

continue to build research tools and links to other data to further enhance the value of patent data. For example, Brian Silverman constructed and made widely available a concordance that links the International Patent Classification system to the U.S. Standard Industrial Classification system at the four-digit SIC level (Silverman, 1999).

So, how is this brief history of major contributions to the value of patent data related to current strategy research? Innovation-related strategy research has increasingly been based on patent data. This is largely due to the combination of a trend towards demands for increasingly sophisticated statistical analyses, often requiring larger sample sizes, and the decreasing cost of accessing and linking patent data. This would not be problematic, even if the patent channel was known to be small relative to other channels of knowledge transfer, if we knew the patent channel was representative of other channels. However, in Agrawal and Henderson (2002), we show that it is not.

In particular, we show that a largely different set of firms accesses knowledge through publications compared to the set that accesses knowledge through patents in our sample of two engineering departments at MIT. This raises a serious concern. How generalizable are our innovation-based results, which are overwhelmingly based on patent data? If the patent channel is both small and not representative, then to what degree has the field been predominantly focused on non-dominant industry phenomena? Has the focus of the strategy literature been dangerously misguided by the availability and popularity of patent data?

Perhaps not. As a field, however, we must be sure. To this end, an important area for future innovation-related strategy research is the exploration of technological inventions that are not patented. The direction of this research is twofold. First, we must directly compare patented to non-patented inventions. In what important ways do they systematically differ? How does the underlying knowledge differ? To what extent do the inventors differ? In what manner do the firms that acquire patented versus non-patented technology differ? How do the transfer mechanisms and contracts differ? Second, using non-patented invention data, we must confirm existing results that have entered the strategy literature canon to understand the boundaries of generalizability and hence the limitations to theory that is predicated on these patent-oriented findings.

Patenting Does Not Diminish Publishing

From a policy perspective, perhaps the most controversial argument advanced in our paper is that patenting activity does not seem to diminish publishing activity. This may seem surprising. At minimum, if researchers face binding budget constraints on their time (and all they do otherwise is publish), then efforts used in patenting are necessarily taken away from publishing. Perhaps of even greater concern is the possibility that researchers who might have otherwise worked on topics of a more fundamental nature, which the private sector does not address due to appropriability problems, are drawn towards more applied topics they can patent for personal pecuniary gain. Not surprisingly, since the public funding of university research is precisely predicated on addressing a market failure in order

to provide research that the market would not provide on its own, the notion that patenting may shift the focus of research is of considerable concern to policymakers and welfare economists (see Mowery et al (2004) for an overview).

In Agrawal and Henderson (2002), we report that our data did not provide evidence that more patenting results in less publishing, though at the same time noting our sample may not be representative as it was drawn from only two departments at a single university with a notably unique culture particularly supportive of commercializing research. Since then, however, more than half a dozen studies have been carried out using different data and without exception have reported results generally consistent with our findings from MIT. Using data drawn from multiple US campuses, Markiewicz and DiMinin (2005) and Goldfarb et al (2007) examine the patent-publish question and report no evidence of substitution. In addition, using data drawn from campuses in four different European countries, various authors report similar findings. These include K.U. Leuven in Belgium (VanLooy et al, 2006), Max Plank Institute in Germany (Buenstorf, 2005), University Louis Pasteur in France (Carayol, 2007), and various institutions in Italy (Breschi et al, 2007; Calderini and Franzoni, 2004).

Thus, none of these eight studies, which collectively represent data from a wide variety of universities, report evidence indicating that patenting substitutes for publishing.[2] This

[2] While I know of no reported evidence of a systematic decline in individual publishing as a result of patenting, Murray and Stern (2006) use patent-paper pair data to present compelling evidence that although publications linked to patents are associated with a higher overall citation rate, after the

leaves us with a puzzle of great import – why not? Why does patenting activity not detract from publishing? It may be that publishing is not a sensitive margin. That is, either hours spent on patenting are reallocated from activities other than publishing or professors become more efficient when they engage in patenting such that they can still produce the same publishing output in fewer hours. For example, the opportunity to patent may create higher incentives for researchers to address real problems faced by industry, which may in turn lead to a sharper focus on better research questions. Such a focus may result in an overall higher productivity, generating more patents *and* papers.

The empirical evidence reported to date does not answer the question of *why* patenting activity does not diminish publishing – it merely sets the stage for it. This presents an exciting new direction for strategy research. Cockburn and Henderson (1998) argue that a corporate culture open to publishing and collaborative "connectedness" to university research may increase researcher productivity and hence firm performance. They conjecture that this is because the connected firm enjoys a greater absorptive capacity. But what do we know about the individual researcher's utility function?[3] Why do inventors allocate their time in the manner they do? What are the researcher's sensitive margins in terms of productivity? Perhaps most importantly, what factors influence the topics that researchers choose to investigate?

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patent is actually issued the rate declines substantially (by 9-17%). They interpret their findings as evidence of an anti-commons effect that results from moving intellectual property from the public into the private domain.

[3] For example, Stern (2004) provides insight into the utility function of researchers by empirically showing that scientists value scientific freedom.

In the field of strategy, we now need to enhance our understanding of the individual researcher. We need to understand why patenting does not substitute for publishing. Since the importance of inventions is not uniformly distributed but rather heavily skewed, the behavior of individual inventors can quite directly influence firm performance. Ironically, then, one of the most promising lines of inquiry into the relationship between innovation and firm performance is not necessarily at the level of the firm but at better understanding the individual inventor.

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